

#5



Patent  
Attorney's Docket No. 027557-083

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of )  
Gunnar KLINGHULT et al. ) Group Art Unit: 2643  
Application No.: 10/011,439 ) Examiner: Unassigned  
Filed: December 11, 2001 )  
For: COMMUNICATION SYSTEMS )

**CLAIM FOR CONVENTION PRIORITY**

Assistant Commissioner for Patents  
Washington, D.C. 20231

Sir:

The benefit of the filing date of the following prior foreign application in the following foreign country is hereby requested, and the right of priority provided in 35 U.S.C. § 119 is hereby claimed:

United Kingdom Patent Application No. 0030279.4


Filed: December 12, 2000

In support of this claim, enclosed is a certified copy of said prior foreign application. Said prior foreign application was referred to in the oath or declaration. Acknowledgment of receipt of the certified copy is requested.

Respectfully submitted,

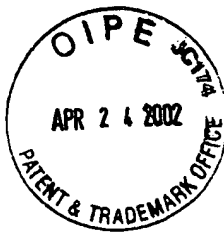
BURNS, DOANE, SWECKER & MATHIS, L.L.P.

Date: April 24, 2002

By:   
Kenneth B. Leffler  
Registration No. 36,075

P.O. Box 1404  
Alexandria, Virginia 22313-1404  
(703) 836-6620

**THIS PAGE BLANK (USPTO)**



INVESTOR IN PEOPLE

#5  
B.P.  
6-182

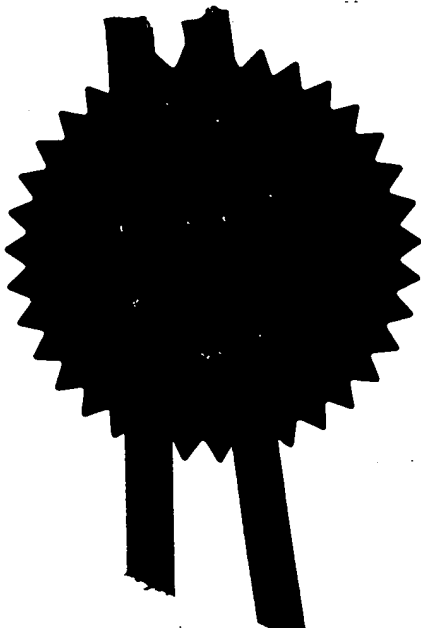
The Patent Office  
Concept House  
Cardiff Road  
Newport  
South Wales  
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.



Signed

*Evans*

Dated 10 December 2001

**THIS PAGE BLANK (USPTO)**

**Request for grant of a patent**

*See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)*

The Patent Office

Cardiff Road  
Newport  
Gwent NP9 1RH

1. Your reference

HL76412/000/CIV

2. Patent application number  
(The Patent Office will fill in this part)

12 DEC 2000

0030279.4

3. Full name, address and postcode of the or of each applicant (*underline all surnames*)

TELEFONAKTIEBOLAGET LM ERICSSON (publ)  
SE-126 25 Stockholm  
Sweden

Patents ADP number (*if you know it*)  
If the applicant is a corporate body, give the country/state of its incorporation

00763730001  
Sweden

4. Title of the invention  
COMMUNICATION SYSTEMS

5. Full name of your agent (*if you have one*)

Haseltine Lake & Co.

"Address for service" in the United Kingdom to which all correspondence should be sent (*including the postcode*)

Imperial House  
15-19 Kingsway  
London WC2B 6UD

Patents ADP number (*if you know it*)

34001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (*if you know it*) the or each application number

Country

Priority application number  
(*if you know it*)

Date of filing  
(*day/month/year*)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing  
(*day/month/year*)

8. Is a statement of inventorship and of right to a grant of patent required in support of this request? (*Answer "Yes" if:*  
a) any applicant named in part 3 is not an inventor, or  
b) there is an inventor who is not named as an applicant, or  
c) any named applicant is a corporate body.  
See note (d))

Yes

**THIS PAGE BLANK (USPTO)**

# Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form -

Description 6

Claim(s) 2

Abstract 1

Drawing(s) 2

10. If you are also filing any of the following,

Priority documents n/a

Translations of priority documents n/a

Statement of inventorship and right to a grant of patent (*Patents Form 7/77*) -

Request for preliminary examination and search (*Patents Form 9/77*) 1

Request for substantive examination (*Patents Form 10/77*) -

Any other documents (please specify) -

11. I/We request the grant of a patent on the basis of this application

Signature

Date  
12 December 2000

12. Name and daytime telephone number of person to contact in the United Kingdom

Mr. Chris Vigars

[0117] 9103200

## Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

## Notes

- If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.
- Write your answers in capital letters using black ink or you may type them.
- If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
- If you have answered "Yes" Patents Form 7/77 will need to be filed.
- Once you have filled in the form you must remember to sign and date it.
- For details of the fee and ways to pay please contact the Patent Office.

**THIS PAGE BLANK (USPTO)**



COMMUNICATION SYSTEMS

The present invention relates to communication systems, and in particular, to communication systems utilising radio frequency (RF) signals.

BACKGROUND OF THE INVENTION

Mobile telecommunication systems make use of radio frequency (RF) signals to communicate with mobile terminals such as mobile telephones. Mobile telephones and audio accessories for mobile telephones must have at least one audio amplifier in order to reproduce sound from a phone call or other audio signal for output to a user via a loudspeaker. Conventional solutions provide a class A, AB or B amplifier as the audio amplifier in such terminals. However, such amplifiers are sensitive to RF signals, and so various techniques are used to minimise RF interference in audio circuits today. Each circuit (each product) needs its own different solution to minimise the RF interference. There is thus no "standard" solution to use in all cases. Used techniques include the addition of decoupling capacitors or inductors in the audio paths and on supply leads. This will often impair the audio performance in other ways and is thus almost always a compromise.

As mentioned, audio amplifiers used in conventional mobile telephones are sensitive to radio frequency. Digital communication systems often use pulsed RF signals, for example in GSM the transmitter is pulsed with a 217 Hz which can be heard as a bumble bee like sound in the loudspeaker after unintentional detection in the analogue audio amplifier. In the Bluetooth (TM) wireless system the RF is pulsed at 1600 Hz, and this can be heard as a high pitch whine.

It is anticipated that future mobile telephones will make use of large piezo electric loudspeakers, which creates the need for high drive voltages to the speaker since it has very high impedance. This further  
5 implies that the use of conventional audio amplifiers will result in increased sensitivity to RF disturbances.

In addition, functions like the MPEG3 audio player require a fairly high audio output and when in use  
10 tends to be used for extended periods of time which consumes a large amount of power.

It is therefore desirable to provide an audio amplifier for a mobile telephone which can avoid the RF interference and reduce the amount of battery power  
15 used.

#### SUMMARY OF THE PRESENT INVENTION

According to one aspect of the present invention, there is provided a mobile telephone which includes an  
20 audio output stage for supplying audio signals to a loudspeaker, wherein the audio amplifier stage is provided by a class D amplifier.

It is emphasised that the term "comprises" or "comprising" is used in this specification to specify  
25 the presence of stated features, integers, steps or components, but does not preclude the addition of one or more further features, integers, steps or components, or groups thereof.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Figures 1 and 2 illustrate respective previously-  
30 considered audio amplifiers for use in mobile telephones; and

Figure 3 illustrates an audio amplifier embodying  
35 the present invention for use in a mobile telephone.

Figure 4 shows a mobile telephone incorporating the audio amplifier of Figure 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

5        Figure 1 illustrates a previously considered audio amplifier for use in a mobile telephone. The audio amplifier receives a digital encoded signal 1 from the digital mobile telephone circuitry (not shown). The digital encoded signal 1 is converted to an analogue  
10        signal 4 by a digital/analogue converter 2. Typically, the digital encoded signal would be a pulse code modulated signal received from a speech coder/decoder (codec) device. The analogue signal 4 is particularly susceptible to interference from electromagnetic RF  
15        signals (EMI) 3, which cause the signal 4 to become noisy.

      The analogue signal 4 is amplified by a linear amplifier 5 and is supplied to a sound generating device 6. The sound generating device 6 outputs an  
20        audio signal 7, which is an amplified version of the analogue signal 4.

      Figure 2 illustrates a second previously considered audio amplifier for use in a mobile  
-telephone. US-5,410,592 shows a class D audio  
25        amplifier for driving a paging loudspeaker in a fixed line telephone. The Figure 2 amplifier is similar to the Figure 1 amplifier, with the exception that the linear amplifier 5 of Figure 1 is replaced by three components in the Figure 2 device. The analogue signal  
30        4 produced by the digital analogue converter unit 2 is converted to a pulse width modulated signal for input to a power switching stage 9. A band pass filter 10 filters the output from the power switching stage, for supply to the sound generating device 6. The sound  
35        generating device 6 produces an audio output signal 11.

As with the Figure 1 embodiment, the amplifier suffers from signal degradation due to electromagnetic interference 3 interfering with the analogue signal 4.

5        Figures 3 and 4 illustrate one embodiment of the present invention which overcomes the disadvantages of the amplifiers of Figures 1 and 2.

10        Figure 4 shows a digital mobile phone 50, for example operating in the GSM system, although the invention is applicable to all devices which transmit under any Time Division Multiple Access (TDMA) system, or under the Wideband Code Division Multiple Access (W-CDMA) system. For example, the invention is generally applicable to portable radio communication equipment or mobile radio terminals, such as mobile telephones, 15        pagers, communicators, electronic organisers, smartphones, personal digital assistants (PDAs), or the like, and the term "mobile telephone" is used broadly to encompass all such devices.

20        Speech inputs at a microphone 52 are processed at baseband in circuitry 54, then upconverted to RF and further processed, for example amplified, in RF transmitter circuitry 56. The resulting signals are transmitted over the air interface by an antenna 58.

25        Signals received at the antenna 58 are supplied to RF receiver circuitry 60, where they are downconverted to baseband and converted to digital form, and they are then processed in digital baseband receiver circuitry 62. The resulting signals are used to drive a loudspeaker 64.

30        The baseband and RF circuit blocks 54, 56, 60, 62 are controlled by control circuitry 66. In particular, in a system as shown, the antenna can either receive or transmit signals at any time. When the RF transmitter circuitry 56 is switched on, the RF receiver circuitry 35        60 is switched off, and vice versa. However, the

digital baseband receiver circuitry 62 remains switched on even when the RF receiver circuitry 60 is switched off, so that it can provide a continuous output to the user.

5           The digital baseband receiver circuitry 62 can also receive other digital input signals, for example an input from an MP3 or other audio player, which can for example be connected as an accessory to the phone 50.

10           Figure 3 is a block schematic diagram showing relevant parts of the digital baseband circuitry 62, including a digital code to pulse width encoder 12 which receives a digital encoded signal 1 from the speech decoder of the mobile telephone, and converts it  
15           to a pulse width modulated (PWM) signal. That is, the widths of the pulses in the PWM signal then carry the audio information. The pulse width modulated signal is supplied to a power switching stage 14 which amplifies the signal and supplies an output to a band pass filter  
20           16. The band pass filter 16 filters the signal to provide a suitable driving signal for supply to a sound generating device 18 (the speaker 64 in Figure 4) which outputs a clean audio signal 20.

          It will be appreciated that the power switching  
25           stage 14 and filter 16 provide a class D amplifier. The basic power output stage of a class D amplifier is a switching stage and thus operates digitally. This gives a low output impedance with only fully switched on or fully switched off transistors. The class D  
30           amplifier can thus not detect RF signals, and cannot be subject to RF interference. In addition, a class D amplifier has a theoretical efficiency of up to 100% and an efficiency of 90 to 98% in real applications.

          Driving the loudspeaker with a digital signal via  
35           such a class D amplifier in a mobile telephone or its

accessories gives various benefits. The use of a class D amplifier achieves elimination of RF disturbances, provides greater efficiency for power use, it eliminates a lot of analogue circuitry which leads to simpler and smaller circuitry, the class of the amplifier has lower current consumption, lower power dissipation and uses less silicon area than the previously considered audio amplifier stages. In addition, a class D amplifier can generate high voltages required to drive a piezo electric loudspeaker.

Further, in accordance with the invention, there is no analogue signal present in the part of the circuitry which remains switched on at all times. Since it is such analogue signals which are subject to interference from the transmitter to produce the "bumble bee" interference mentioned previously, the circuit as described herein avoids this problem.

There is thus described a circuit which is efficient and also provides a high quality audio output.

CLAIMS:

1. A digital mobile telephone comprising:  
digital circuitry which is operable to output  
encoded digital signals representing audio signals; and  
5 an audio output stage connected for receiving  
encoded digital signals from the digital circuitry and  
operable to output drive signals for driving an audio  
output device,

wherein the audio output stage includes a class D  
10 amplifier which is connected for receiving the encoded  
digital signals and is operable to output amplified  
digital signals as the output drive signals.

2. A mobile telephone as claimed in claim 1,  
wherein the audio output stage comprises:  
15 an encoder which is connected to receive the  
encoded digital signal from the digital circuitry, and  
is operable to convert received signals to pulse width  
coded digital signals.

3. A mobile telephone as claimed in claim 2,  
20 wherein the audio output stage comprises:  
a power switching unit connected to receive pulse  
width coded signals from the encoder and operable to  
output amplified digital signals; and  
a filter connected to receive amplified digital  
25 signals from the power switching unit and operable to  
supply a filtered output signal to a sound generating  
device.

4. A mobile telephone as claimed in claim 3,  
wherein the filter is a band pass filter.

30 5. A mobile telephone as claimed in any  
preceding claim, comprising:  
transmitter circuitry; and  
RF receiver circuitry;  
wherein the RF receiver circuitry is switched off  
35 when the transmitter circuitry is active, while the

-8-

digital circuitry and audio output stage remain  
switched on.

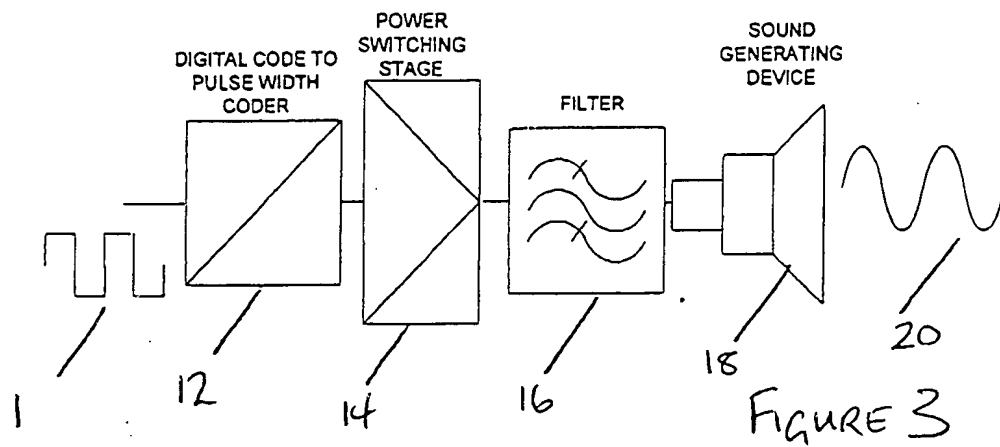
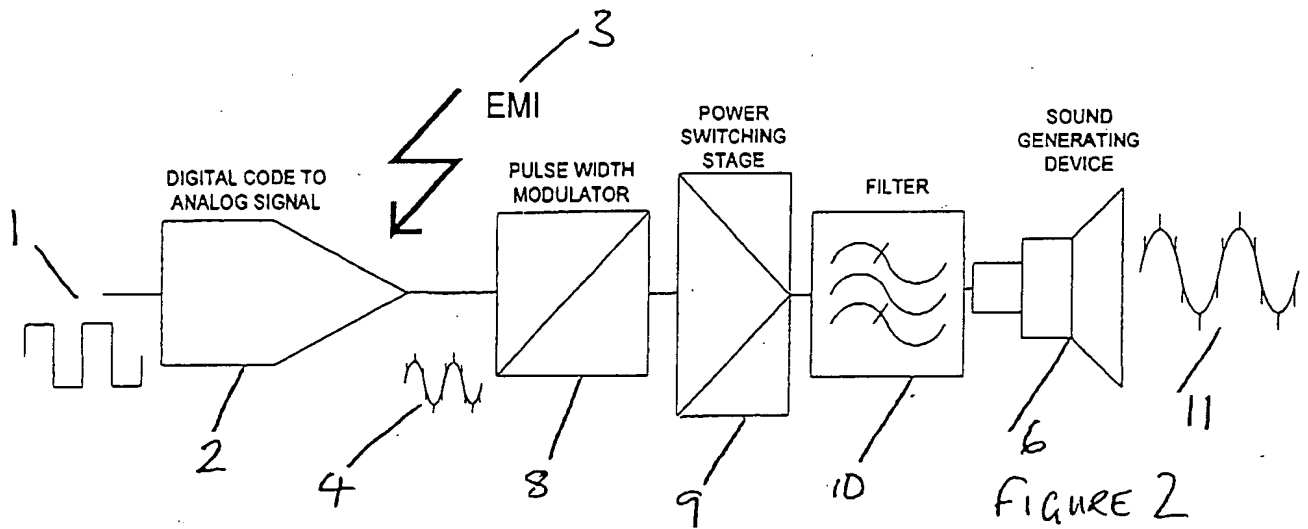
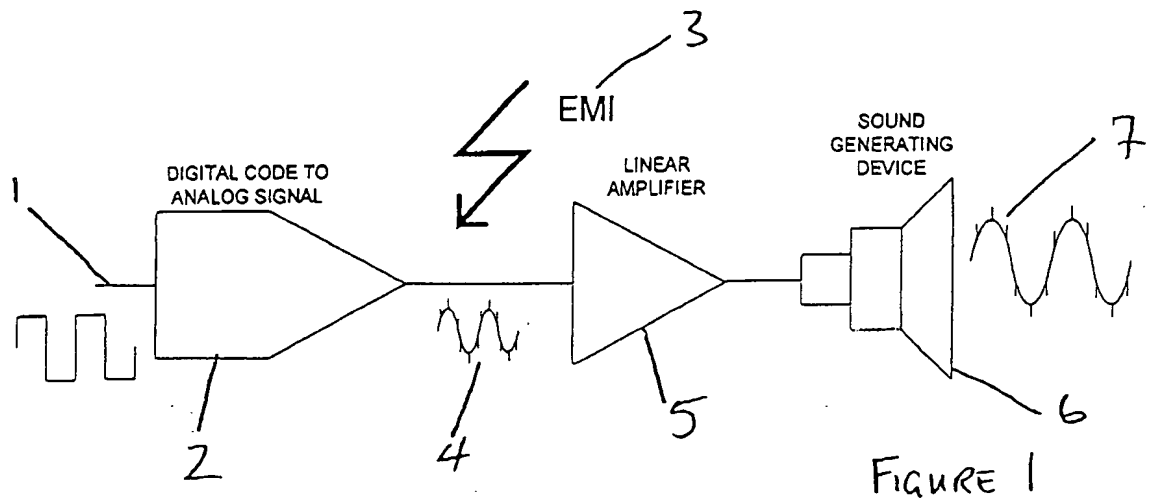


ABSTRACT

COMMUNICATION SYSTEMS

There is provided a mobile telephone in which a  
class D amplifier is used to amplify the signals  
5 supplied to a loudspeaker. The baseband receiver  
circuitry, which remains switched on while the  
transmitter is active, processes only digital signals,  
thereby avoiding the "bumble bee" effect caused by  
signals from the transmitter interfering with signals  
10 in the receiver circuitry.

**THIS PAGE BLANK (USPTO)**



**THIS PAGE BLANK (USPTO)**

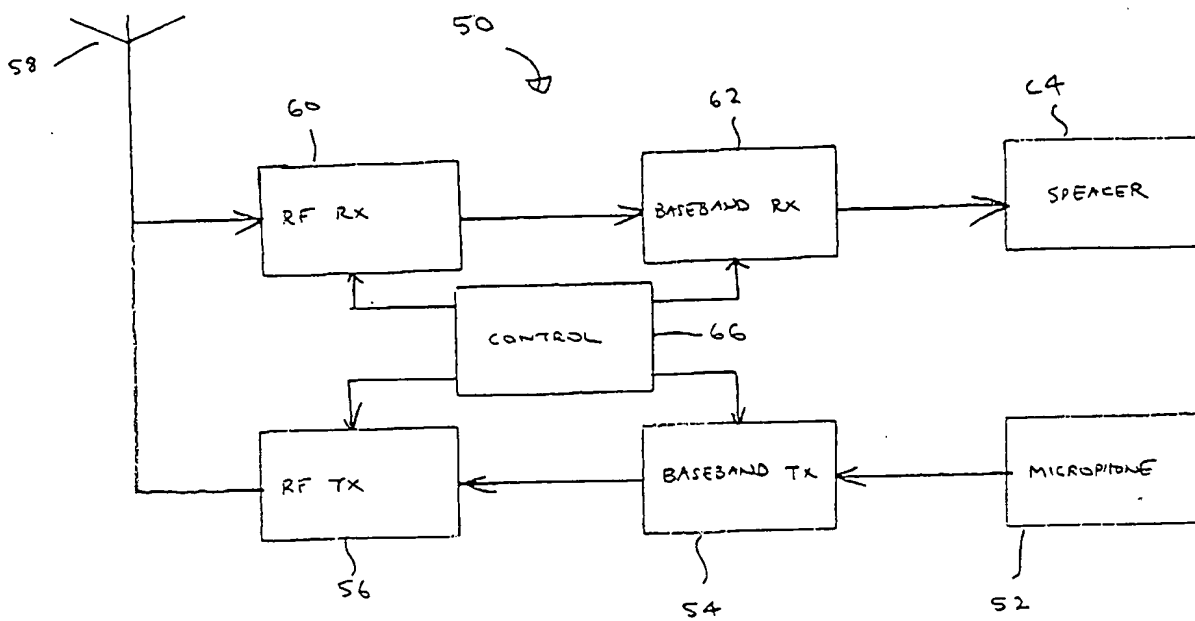


FIG. 4

**THIS PAGE BLANK (USPTO)**